

# **POWER BANK TESTING**

## **TEST RESULTS**

**PREPARED ON:**

**2 December 2021**

**PREPARED FOR:**

**Sullivan and Triggs, LLP**

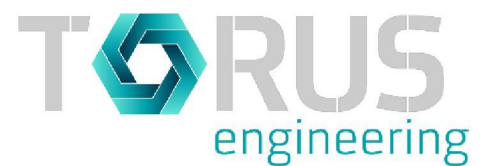
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## OBJECTIVE:

The purpose of this document is to present the findings and results of the Power Bank Testing as outlined in the test plan presented to Sullivan and Triggs, LLP for product testing of Belkin's Pocket Power 10K Power Bank (Model F7U020, Figure 1).



*Figure 1: Pocket Power 10K Power Bank (Portable Charger, Model F7U020) DUT*

Source: <https://www.belkin.com/us/chargers/power-banks/pocket-power-10k-power-bank-portable-charger/p-p-f7u020/>

## REPORT OVERVIEW

This report covers the three stages of the power bank testing:

1. iPhone Battery Depletion: Ensure all iPhone 7 batteries are fully depleted.
2. DUT Charging: Ensure power banks (DUTs) are fully charged.
3. iPhone Charging with DUT: Measure DUT performance when paired with an iPhone 7.

These three individual tests work to verify the:

- Number of charges and charging time available when the power banks are paired with various iPhone 7 devices.
- Electric power (voltage and current) delivered by the power bank to the iPhone 7 during charging.

See *Power Bank Testing: Test Plan* for more information regarding test plan, setup, and schematics.

See *Power Bank Test Sheet* for all test logs, notes, and further details.

## TEST VIDEO CAPTURE

Throughout all testing, an iPhone was used to record and capture video. The iPhone was begun at the beginning of each test day and left to run throughout the day. No testing or device handling (unless otherwise noted in test logs and notes) occurred off-camera.

The recording iPhone was placed on alongside the wall adjacent to the testing area to ensure clear and unobstructed viewing as shown in Figure 2.

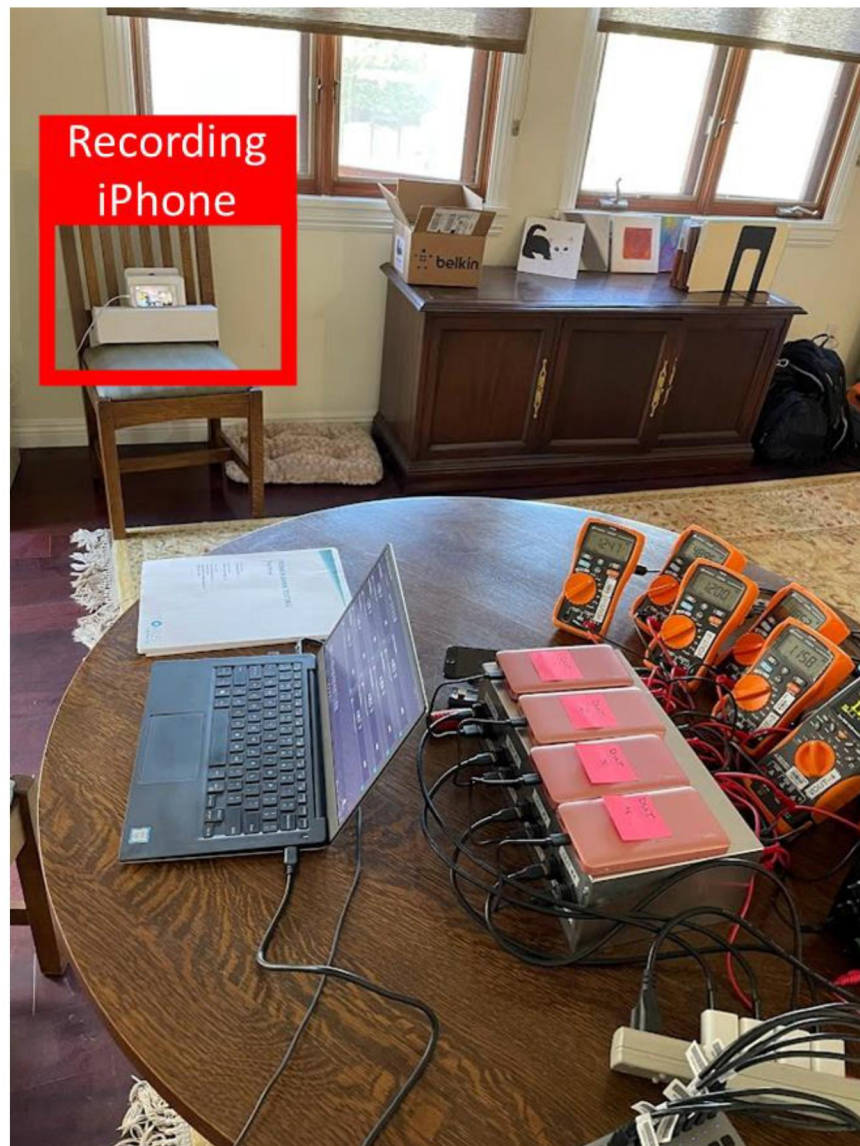


Figure 2: Video Capture Setup

## TEST DEVICES

All Devices Under Test (DUT) information and Apple iPhone information can be found in Table 1 and

Table 2. Supporting screenshots for each iPhone can be found in the following figures.

See *Power Bank Testing: Test Plan* for further information regarding supporting test equipment.

**NOTE: The plaintiff's device (belonging to Miley Lenore, recovered by B. Carneiro on 3/11/2019, and provided to Torus Engineering by Gillian Kuhlman on 11/29/2021) corresponds to, and is referred to as, DUT-1 in all test plans, data, and reports.**

Table 1: Power Bank DUT Devices (Plaintiff's device highlighted yellow)

Name	Description	Model	S/N
DUT-1	Belkin Pocket Power 10K Power Bank	F7U020 1INP11/66/110	4218DO
DUT-2	Belkin Pocket Power 10K Power Bank	F7U020 1INP11/66/110	0819DO
DUT-3	Belkin Pocket Power 10K Power Bank	F7U020 INP11/66/110-1	4218DO
DUT-4	Belkin Pocket Power 10K Power Bank	F7U020 INP11/66/110-1	4518DO

Table 2: Apple iPhone 7 Devices

Name	Description	Model Number	Serial Number	SW Version	Battery Health <sup>1</sup>
iPhone-1	Apple iPhone 7	MNAJ2LL/A	F4GSDU5HHG71	14.8	100%
iPhone-2	Apple iPhone 7	MNAC2LL/A	DX4YGCVDHG6W	14.5.1	98%
iPhone-3	Apple iPhone 7	MN8N2LL/A	C6KT82WJHG73	15.0.1	91%
iPhone-4	Apple iPhone 7	MNAC2LL/A	DX4YGE45HG6W	14.5.1	85%

<sup>1</sup> Battery health as stated by Apple in iPhone settings. Battery health listed refers to iPhone battery health on 12/1/2021.

12:58 PM 15%		12:58 PM 15%	
<a href="#">General</a> <b>About</b>		<a href="#">Battery</a> <b>Battery Health</b>	
Name	DUT-01-100 >	Phone batteries, like all rechargeable batteries, are consumable components that become less effective as they age. <a href="#">Learn more...</a>	
Software Version	14.8		
Model Name	iPhone 7	Maximum Capacity	100%
Model Number	MNAJ2LL/A	This is a measure of battery capacity relative to when it was new. Lower capacity may result in fewer hours of usage between charges.	
Serial Number	F4GSDU5HHG71		
		<b>Peak Performance Capability</b>	
Coverage Expired	>	Your battery is currently supporting normal peak performance.	
		<b>Optimized Battery Charging</b> <input type="checkbox"/>	
Network	Not Available	To reduce battery aging, iPhone learns from your daily charging routine so it can wait to finish charging past 80% until you need to use it.	
Songs	0		
Videos	0		
Photos	6		
Applications	4		

Figure 3: iPhone-1 Summary Screenshots

No SIM 10:21 AM 62%		No SIM 10:21 AM 62%	
<a href="#">General</a> <b>About</b>		<a href="#">Battery</a> <b>Battery Health</b>	
Name	DUT-02-099 >	Phone batteries, like all rechargeable batteries, are consumable components that become less effective as they age. <a href="#">Learn more...</a>	
Software Version	14.5.1		
Model Name	iPhone 7	Maximum Capacity	98%
Model Number	MNAC2LL/A	This is a measure of battery capacity relative to when it was new. Lower capacity may result in fewer hours of usage between charges.	
Serial Number	DX4YGCVDHG6W		
		<b>Peak Performance Capability</b>	
Coverage Expired	>	Your battery is currently supporting normal peak performance.	
		<b>Optimized Battery Charging</b> <input type="checkbox"/>	
Network	Not Available	To reduce battery aging, iPhone learns from your daily charging routine so it can wait to finish charging past 80% until you need to use it.	
Songs	0		
Videos	0		
Photos	3		
Applications	4		

Figure 4: iPhone-2 Summary Screenshots

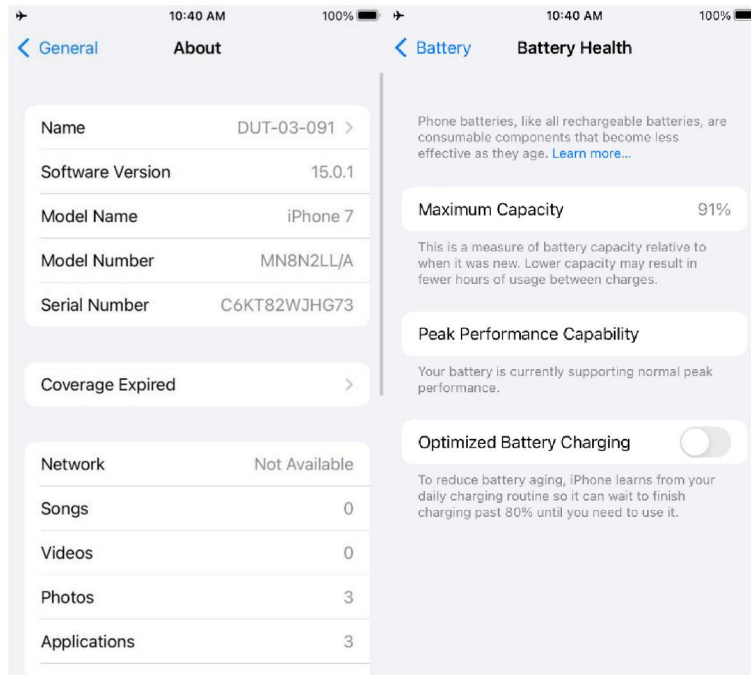


Figure 5: iPhone-3 Summary Screenshots

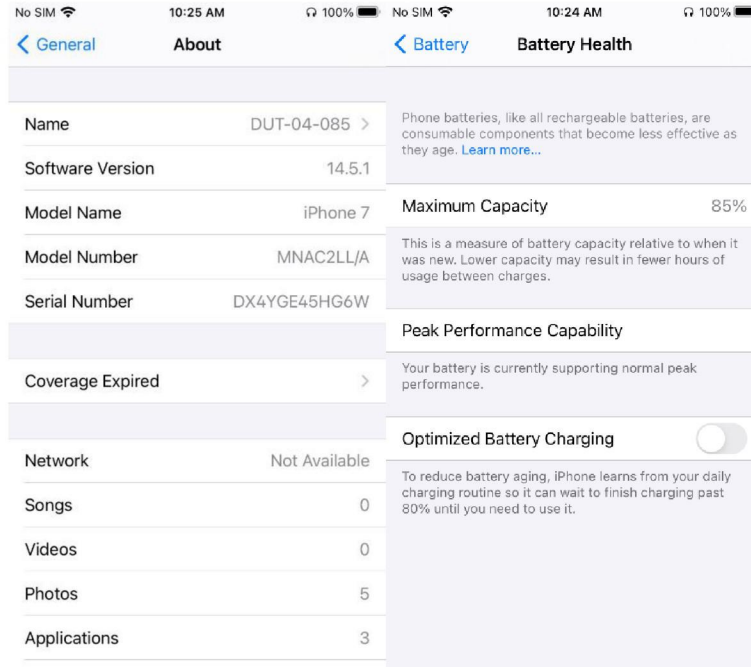


Figure 6: iPhone-4 Summary Screenshots

## TEST 1: IPHONE BATTERY DEPLETION

Test 1 was completed to ensure that all iPhone batteries were depleted to the point that the phone automatically powers down and requests to be charged. This verifies that all phones began charging from the same “dead” state for each cycle of Test 3.

### SUMMARY

There was no data collected throughout the four cycles of Test 1. Screenshots captured by each iPhone at the end of each cycle of Test 3 verify battery charge and discharge.

Table 3 outlines the date and time for the various cycles of Test 1.

*Table 3: Test 1 Log*

Test 1: iPhone Battery Depletion (no data collected)					
Cycle	Date	Start Time	End Time	Total Time	Notes
1	11/30/2021	-	-	-	Phones dead upon arrival to begin testing (11/29/2021) <sup>2</sup>
2	11/30/2021	12:40:00 PM	4:15:00 PM	3.58	
3	11/30/2021	6:38:00 PM	7:30:00 AM	12.85	Phones left to deplete battery overnight, fully depleted when arrived next morning
4	12/1/2021	10:00:00 AM	12:37:00 PM	2.62	DUT-2 fully depleted. iPhone 2 done charging. No need to deplete it.

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<sup>2</sup> Torus Engineering depleted all iPhone batteries prior to arrival for testing.

## TEST 2: DUT CHARGING

Test 2 was completed to ensure that all DUTs (power banks) were fully charged prior to beginning the multiple cycles of Test 1 and Test 3.

**NOTE: The plaintiff's device corresponds to DUT-1 in all test plans, data, and reports.**



*Figure 7: Test 2 Setup*

## SUMMARY

Sullivan and Triggs, LLP provided three new power bank devices (DUT-2, DUT-3, DUT-4) that matched the model of DUT-1. These new power bank devices were delivered the morning of 11/29/2021. The plaintiff's device, DUT-1, had been delivered via FedEx and was unopened. DUT-1 was opened on camera by Torus Engineering representative Zachary Gillan at roughly 10:40 AM (PT).

The DUTs were originally charging on the standard Apple iPhone 5 W (5 VDC, 1 Amp) provided charging blocks. To increase charging speed, 12 W (5 VDC, 2.4 Amp) charging blocks were purchased from Target and used to replace the original 5 W charging blocks.

After completion of Test 2 on 11/29/2021, the DUTs were left plugged in to the power supplies overnight in order to maintain charge before beginning Test 3 on 11/30/2021.

- The swapping of charging blocks does not affect test results of this or any other test performed, as Test 2 was used to verify operation and charging of only the DUTs themselves.
- Test 2 was performed only once, on 11/29/2021. The DUTs never received any supplemental charging (recharging) between cycles of Test 1 and Test 3.

Test 2 was completed when all four LEDs on each DUT were on with no blinking, noting that charging was complete, as shown in Figure 8.



*Figure 8: Test 2 Completion (4 stable LEDs on each DUT)*

Table 4 outlines Test 2 details, including: date, time, and DUT starting charge, while **Error! Reference source not found.** outlines the data files, their measurements, and their location.

Table 4: Test 2 Log

DUT	Date	Start Time	Starting LED (Charge %)	End Time	Total Time
1	11/29/2021	10:46:00 AM	0	7:10:00 PM	8.40
2			1	5:55:00 PM	7.15
3			1	5:55:00 PM	7.15
4			0	7:10:00 PM	8.40

Figure 9 depicts the power drawn by the DUTs from the wall power supplies while charging, as measured by the test circuit and Keysight Digital Multi-Meters.

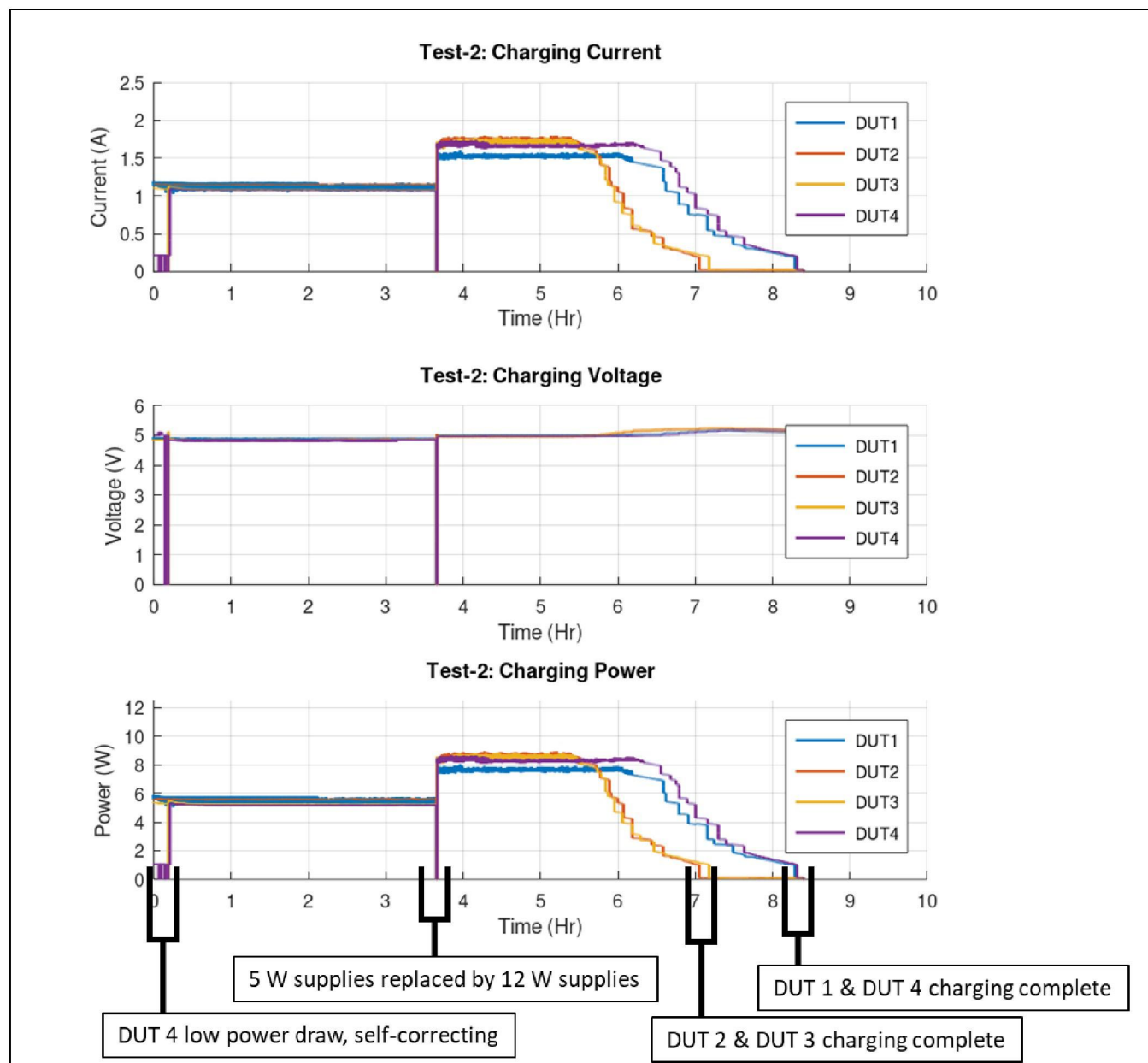


Figure 9: Test 2 DUT Charging Power Draw

## TEST 3: IPHONE CHARGING WITH DUT

Test 3 measured the DUT performance when paired with an iPhone 7 device. Test 3 was the operation of the DUTs charging their respective iPhones. Test 3 was performed after Test 2. A cycle of Test 1 was completed before each cycle of Test 3.

**NOTE:** The plaintiff's device corresponds to DUT-1 in all test plans, data, and reports.



Figure 10: Test 3 Setup

## SUMMARY

There was a total of five Test 3 cycles performed. All four DUTs and iPhones were used in cycles 3-1, 3-2, and 3-3. DUT-1, DUT-3, and DUT-4 were then used in cycle 3-4, before just DUT-3 was used in cycle 3-5.

- Tests 3-1 and 3-2 were completed 11/30/2021.
- Tests 3-3, 3-4, and 3-5 were completed 12/1/2021. All DUTs were left unplugged (not charging) overnight between tests 3-2 and 3-3.

For all Test 3 cycles (excluding 3-5), the DUTs were paired with their respective iPhones, i.e. DUT-1 with iPhone-1, DUT-2 with iPhone-2, etc.

DUT-3 was the only DUT remaining after Test 3-4. With minimal battery remaining, it was determined to pair iPhone-4 with DUT-3 for Test 3-5. This was done to prevent having to complete another cycle of Test 1 (roughly 3 hours) knowing that minimal battery charge remained in DUT-3 (DUT-3 LED status had displayed 1 LED for nearly 1 hour).

The DUTs performance, as noted below, are captured in Figure 11 and Figure 12, the average DUT performance while charging an iPhone 7 was 3.43 times (3.41 times from a dead state if Test 3-5 is excluded).

- DUT-2 was fully depleted in cycle 3-3, charging iPhone-2: 2.71 times.
- DUT-1 was fully depleted in cycle 3-4, charging iPhone-1: 3.15 times.
- DUT-4 was fully depleted in cycle 3-4, charging iPhone-4: 3.76 times.
- DUT-3 was fully depleted in cycle 3-5, charging iPhone-3/iPhone-4: 4.11 times.
  - Charging iPhone-3: 4 times
  - Charging iPhone-4: 0.11 times

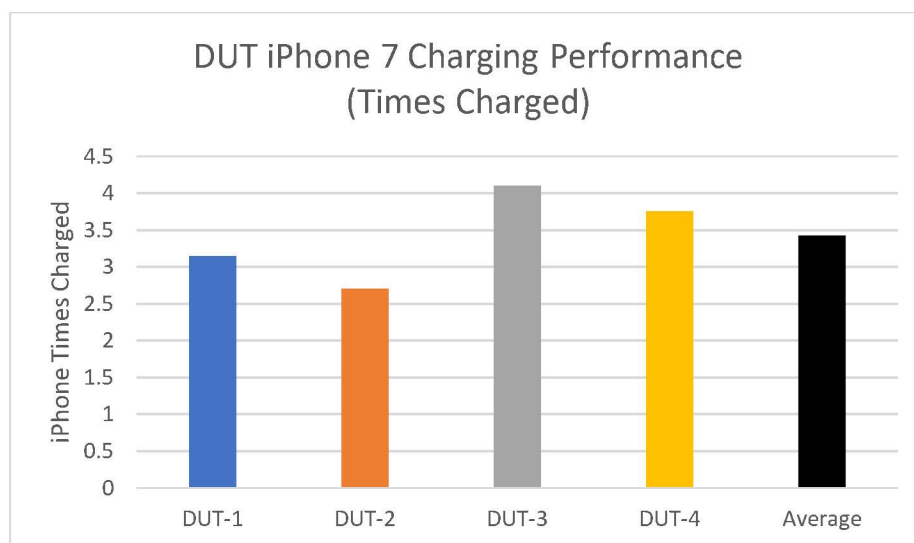


Figure 11: DUT Overall Charging Performance

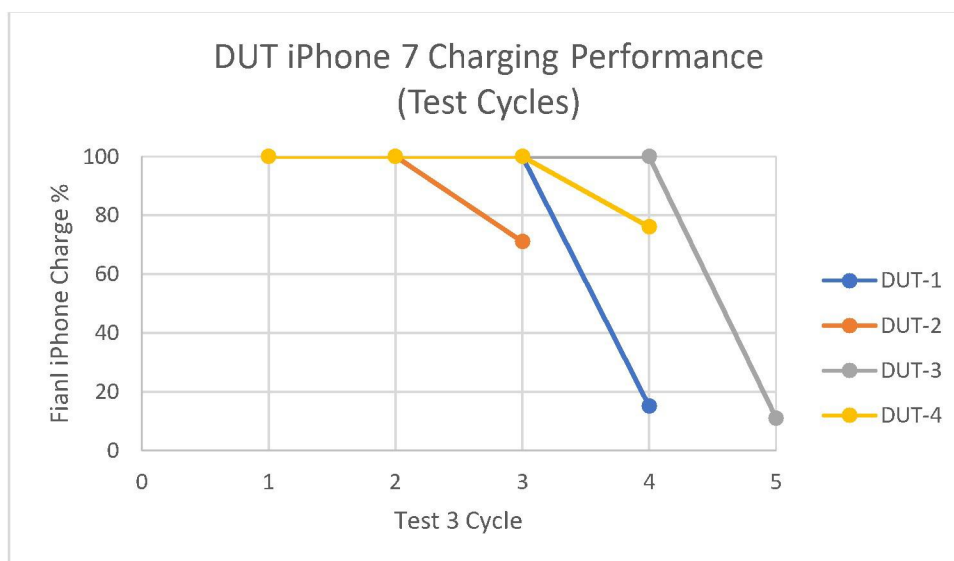


Figure 12: DUT Charging Performance vs Test Cycle

In USB charging, the power supply (DUT in this test) does not determine the power to be supplied, rather, the power draw is controlled by the receiving USB device (iPhone 7 in this test). The power drawn by the iPhones was captured by the test circuit, and is displayed for each DUT below. The power draws show the standard decrease in power as the iPhone battery charge increases. The immediate power outages note the depletion of the DUT for the respective test cycle.

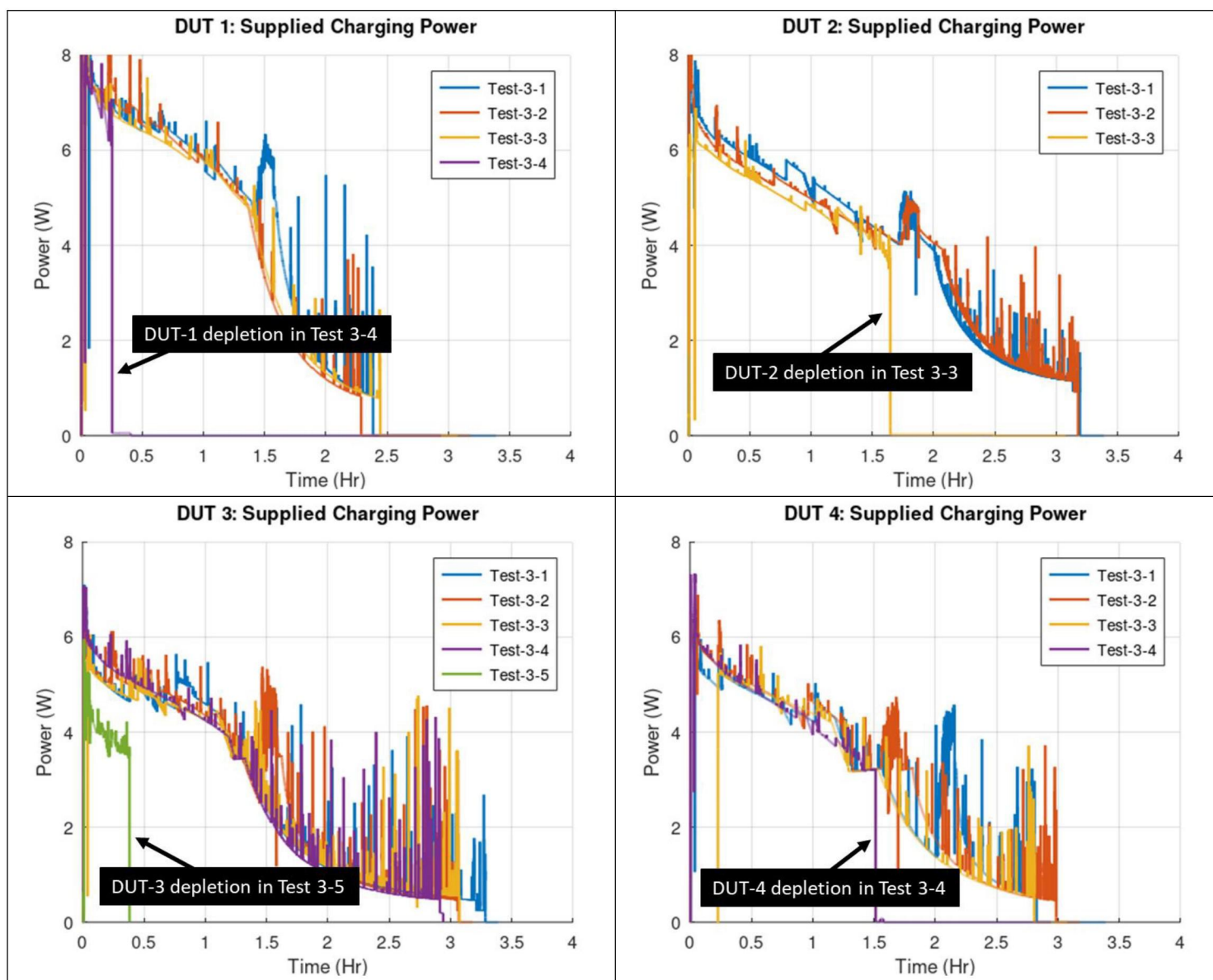


Figure 13: DUT Supplied Power vs Test Cycles

After completion of each cycle, a screenshot was collected from each iPhone's battery statistics in order to further verify charge and discharge times.

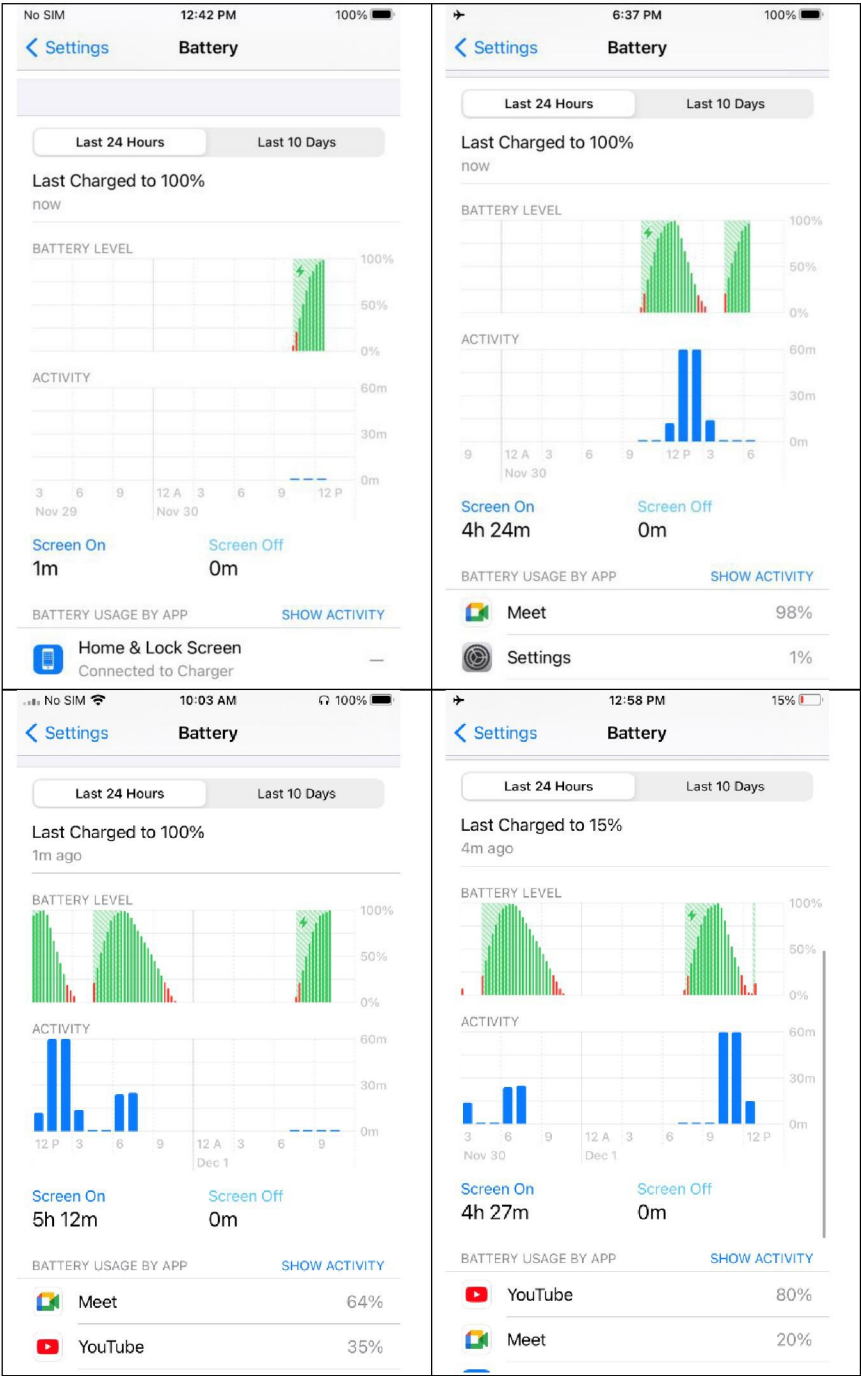


Figure 14: iPhone-1 Charging Summary Screenshots

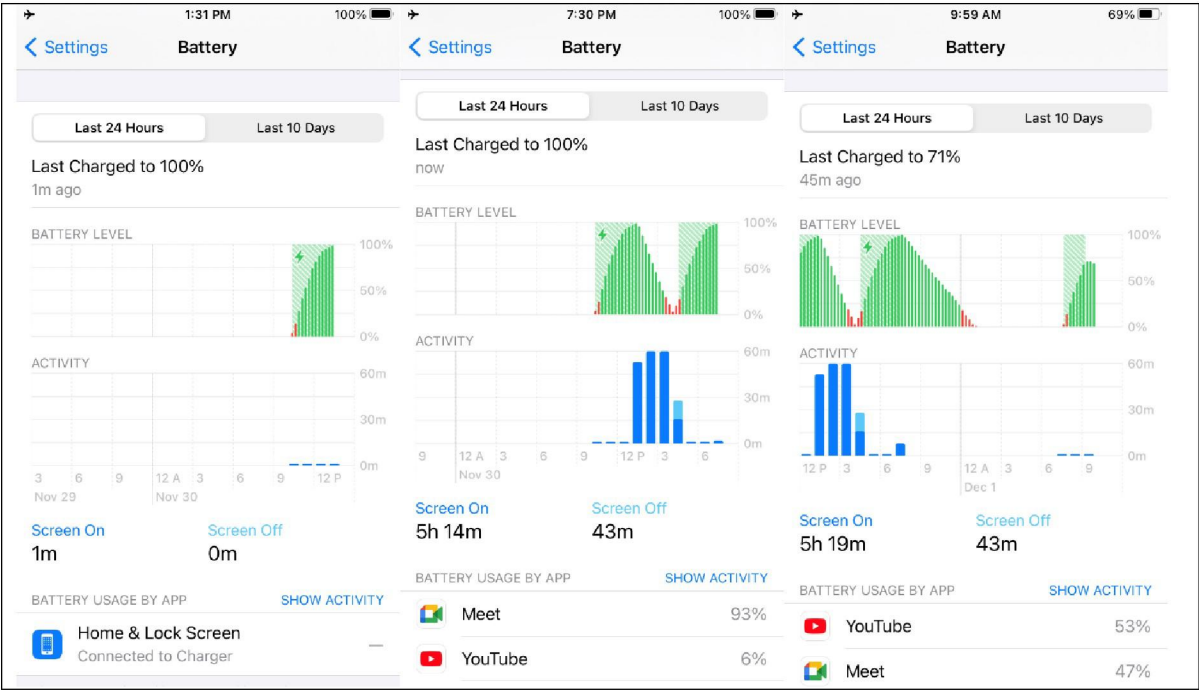


Figure 15: iPhone-2 Charging Summary Screenshots

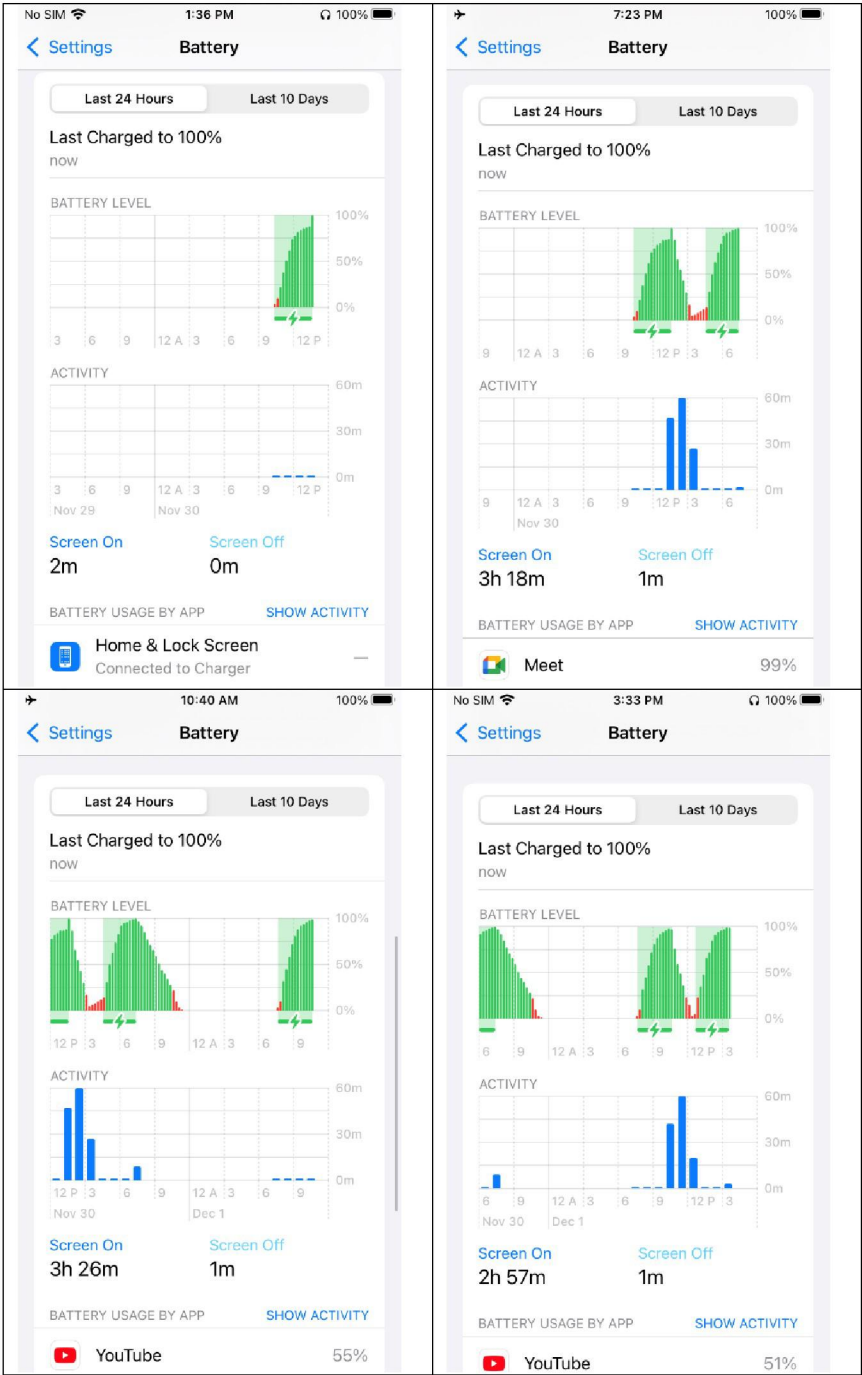


Figure 16: iPhone-3 Charging Summary Screenshots

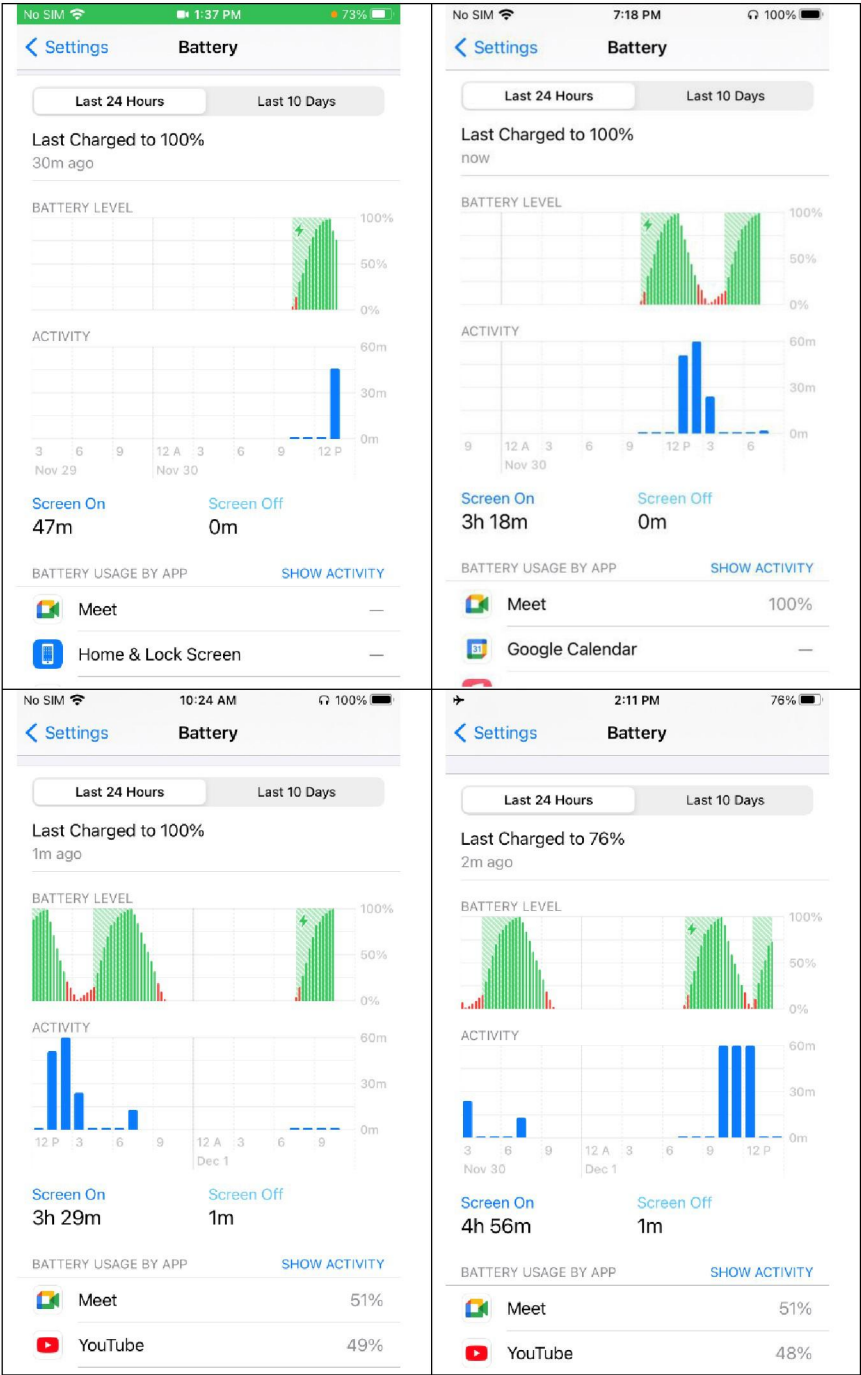


Figure 17: iPhone-4 Charging Summary Screenshots<sup>3</sup>

<sup>3</sup> iPhone-4 was reset after DUT-4 was depleted during Test 3-4. In doing so, there was not sufficient data for the iPhone to track battery statistics for iPhone-4's charging during Test 3-5.

**APPENDIX A: LIST OF RELATED DOCUMENTS**

File	Description	Folder
Power Bank Test Plan - S&T - v03	Test plan	~/Test Docs
Power Bank Test Sheet	Testing spreadsheet and log	~/Test Docs
Power Bank Test Results - S&T	Test results and report	~/Test Docs
-	Test 2 setup and operation photos	~/Test Photos/Test 2
-	Test 3 setup and operation photos	~/Test Photos/Test 3
-	iPhone-X screenshots	~/Test Photos/Test 3/iPhone-X
-	Test-X data	~/Test Data/Test-X
DMM_Data_Output	Data analysis script	~/Test Data
-	Data analysis output figures	~/Test Data/Outputs

**APPENDIX B: TEST DEVICES**

Belkin Power Bank Device List (Updated)			
ID	Description	Model	Serial Number
1	Pocket Power 10K Power Bank	F7U020 1INP11/66/110	4218DO
2		F7U020 1INP11/66/110	0819DO
3		F7U020 INP11/66/110-1	4218DO
4		F7U020 INP11/66/110-1	4518DO

Apple iPhone 7 Device List					
ID	Description	Model	Serial Number	SW Version	Stated Battery Health (11/22/20221)
1	Apple iPhone 7	MNAJ2LL/A	F4GSDU5HHG71	14.8	100
2		MNAC2LL/A	DX4YGCVDHG6W	14.5.1	98
3		MN8N2LL/A	C6KT82WJHG73	15.0.1	91
4		MNAC2LL/A	DX4YGE45HG6W	14.5.1	85

Digital Multi-Meter Device List					
ID	Description	Model	Serial Number	DUT Pairing	Measurement
1	Keysight Handheld DMM	U1233A	MY54490018	1	Current (Vout)
2		U1232A	MY61190016	1	Voltage (Vusb)
3		U1233A	MY54500023	2	Current (Vout)
4		U1232A	MY61160030	2	Voltage (Vusb)
5		U1233A	MY54500039	3	Current (Vout)
6		U1232A	MY61400033	3	Voltage (Vusb)
7		U1253B	MY54480036	4	Current (Vout)
8		U1233A	MY54490005	4	Voltage (Vusb)

**APPENDIX C: TEST DATA FILES***Test 2 Data Log*

DUT	Data Directory	Data Type	DMM S/N	Data File
1	(Test Root Folder)/Test 2	Current	MY54490018	U1233A_MY54490018_132827154541199657.xml
		Voltage	MY61190016	U1232A_MY61190016_132827154539943010.xml
2		Current	MY54500023	U1233A_MY54500023_132827154538676403.xml
		Voltage	MY61160030	U1232A_MY61160030_132827154537430500.xml
3		Current	MY54500039	U1233A_MY54500039_132827154535765990.xml
		Voltage	MY61400033	U1232A_MY61400033_132827154545208830.xml
4		Current	MY54480036	U1253B_MY54480036_132827154543942216.xml
		Voltage	MY54490005	U1233A_MY54490005_132827154542556052.xml

*Test 3 Data Log*

Data Directory	Data Type	DMM S/N	Data File	Notes
(Test Root Folder) /Test 3-1	Current	MY54490018	U1233A_MY54490018_132827820740259312.xml	
	Voltage	MY61190016	U1232A_MY61190016_132827820739650956.xml	
	Current	MY54500023	U1233A_MY54500023_132827820739092438.xml	
	Voltage	MY61160030	U1232A_MY61160030_132827820737747946.xml	
	Current	MY54500039	U1233A_MY54500039_132827820737219439.xml	
	Voltage	MY61400033	U1232A_MY61400033_132827820736680805.xml	
	Current	MY54480036	U1253B_MY54480036_132827820736072420.xml	
	Voltage	MY54490005	U1233A_MY54490005_132827820735382222.xml	
(Test Root Folder) /Test 3-2	Current	MY54490018	U1233A_MY54490018_132828029995627495.xml	
	Voltage	MY61190016	U1232A_MY61190016_132828029994629922.xml	
	Current	MY54500023	U1233A_MY54500023_132828029993562915.xml	
	Voltage	MY61160030	U1232A_MY61160030_132828029992625202.xml	
	Current	MY54500039	U1233A_MY54500039_132828029991678059.xml	
	Voltage	MY61400033	U1232A_MY61400033_132828029990700343.xml	
	Current	MY54480036	U1253B_MY54480036_132828029988745575.xml	
	Voltage	MY54490005	U1233A_MY54490005_132828029987309424.xml	
(Test Root Folder) /Test 3-3	Current	MY54490018	U1233A_MY54490018_132828575852713817.xml	
	Voltage	MY61190016	U1232A_MY61190016_132828575851846139.xml	
	Current	MY54500023	U1233A_MY54500023_132828575849833116.xml	
	Voltage	MY61160030	U1232A_MY61160030_132828575849332647.xml	
	Current	MY54500039	U1233A_MY54500039_132828575848875180.xml	

Power Bank Testing  
Test Results - Appendix D

Data Directory	Data Type	DMM S/N	Data File	Notes
	Voltage	MY61400033	U1232A_MY61400033_132828575848296719.xml	
	Current	MY54480036	U1253B_MY54480036_132828575847789264.xml	Zero'd data until 7:49 AM (unplugged)
	Voltage	MY54490005	U1233A_MY54490005_132828575847052912.xml	
(Test Root Folder) /Test 3-4	Current	MY54490018	U1233A_MY54490018_132828752666785375.xml	
	Voltage	MY61190016	U1232A_MY61190016_132828752666396396.xml	
	Current	-	-	DUT-2 depleted on cycle 3
	Voltage	-	-	
	Current	MY54500039	U1233A_MY54500039_132828752665985017.xml	
	Voltage	MY61400033	U1232A_MY61400033_132828752665555979.xml	
	Current	MY54480036	U1253B_MY54480036_132828752665066781.xml	
	Voltage	MY54490005	U1233A_MY54490005_132828752664488329.xml	
(Test Root Folder) /Test 3-5	Current	-	-	DUT-1 depeleted on cycle 4
	Voltage	-	-	
	Current	-	-	DUT-2 depleted on cycle 3
	Voltage	-	-	
	Current	MY54500039	U1233A_MY54500039_132828770094643795.xml	Started at 75% (86% - 75% = 11%)
	Voltage	MY61400033	U1232A_MY61400033_132828770094055367.xml	
	Current	-	-	DUT-4 depleted on cycle 3
	Voltage	-	-	

## APPENDIX D: TEST NOTES

### Test 2 Notes

Test 2 Notes (11/29)	
10:26:00 AM	Began charging initial DUTs, without DUT #1, no data collected
10:40:00 AM	Began video recording
10:40:00 AM	Opened DUT #1 FedEx packaging
10:45:00 AM	Replaced DUTs #2-4 with new powerbanks delivered this morning
10:45:00 AM	Verified DMM connections and settings, verified data log directory empty, began data acquisition and test.
10:55:00 AM	DUT #4 charging circuit appears to be incorrect.
10:57:00 AM	First tried swapping DUT #3 charging block with DUT #4 charging block. Issue not resolved. Determined to be interior to box.
10:59:00 AM	Issue self resolved. Presume to be belkin powerbank calling for more power now that has more battery charge. (USB power draw controlled by charging device)
2:26:00 PM	Received fast charging blocks from Target. Swapped 1 Amp chargers for fast 2.4 Amp chargers.
7:10:00 PM	Charging completed. Data acquisition stopped. Powerbanks unplugged for end of data acquisition then replugged in to power for overnight.
7:10:00 PM	Video recording stopped

### Test 3 Notes

Test 3 Notes	
Test Notes - cycle 1 (11/30)	
10:05:00 AM	Video recording began.
10:05:00 AM	Found U1253B battery low, swapped battery with new one.
10:10:00 AM	Connected DMMs to laptop, verified connection and settings, verified data log directory empty
10:18:00 AM	Test connections made, DMM acquisition began, DUTs connected, verified all iPhones charging
10:18:00 AM	iPhone 3 placed into airplane mode. Wifi and Bluetooth off.
10:22:00 AM	Verified remaining iPhones all in airplane mode. Wifi and Bluetooth off.
12:41:00 PM	iPhone 1 fully charged. DUT 1 unplugged, screenshot captured.
1:05:00 PM	iPhone 4 fully charged. DUT 4 unplugged, screenshot captured.
1:30:00 PM	iPhone 2 fully charged. DUT 2 unplugged, screenshot captured.
1:35:00 PM	iPhone 3 fully charged. DUT 3 unplugged, screenshot captured.
Test Notes - cycle 2 (11/30)	
4:20:00 PM	Connected DMMs to laptop, verified connection and settings, verified data log directory empty
4:20:00 PM	Test connections made, DMM acquisition began, DUTs connected, verified all iPhones charging
4:34:00 PM	Verified all iPhones in airplane mode, Wifi and bluetooth off.
6:35:00 PM	iPhone 1 fully charged. DUT 1 unplugged, screenshot captured.
7:17:00 PM	iPhone 4 fully charged. DUT 4 unplugged, screenshot captured.
7:22:00 PM	iPhone 3 fully charged. DUT 3 unplugged, screenshot captured.
7:30:00 PM	iPhone 2 fully charged. DUT 2 unplugged, screenshot captured.
7:30:00 PM	Video recording stopped.
Test Notes - cycle 3 (12/1)	

Test 3 Notes	
7:30:00 AM	Started video recording
7:30:00 AM	Found U1253B battery low, swapped battery with new one.
7:35:00 AM	Connected DMMs to laptop, verified connection and settings, verified data log directory empty
7:35:00 AM	Test connections made, DMM acquisition began, DUTs connected, verified all iPhones charging
7:38:00 AM	Verified all iPhones in airplane mode, Wifi and bluetooth off.
7:48:00 AM	Found U1253B was not re-connected after morning battery swap. Re-connected device. Measuring properly. Continue test without interruption.
9:15:00 AM	DUT 2 powerbank depleted. iPhone 2 reached 71% battery capacity.
10:00:00 AM	iPhone 1 fully charged. DUT 1 unplugged, screenshot captured.
10:23:00 AM	iPhone 4 fully charged. DUT 4 unplugged, screenshot captured.
10:40:00 AM	iPhone 3 fully charged. DUT 3 unplugged, screenshot captured.
Test Notes - cycle 4 (12/1)	
12:21:00 PM	Connected DMMs to laptop, verified connection and settings, verified data log directory empty
12:38:00 PM	Test connections made, DMM acquisition began, DUTs connected, verified all iPhones charging
12:40:00 PM	Verified all iPhones in airplane mode, Wifi and bluetooth off.
12:40:00 PM	DUT 2 not tested in this cycle (already depleted)
12:56:00 PM	DUT 1 powerbank depleted. iPhone 1 reached 15% battery capacity.
2:10:00 PM	DUT 4 powerbank depleted. iPhone 4 reached 76% battery capacity.
3:30:00 PM	iPhone 3 fully charged. DUT 3 unplugged, screenshot captured.
Test Notes - cycle 5 (12/1)	
3:41:00 PM	Connected DMMs to laptop, verified connection and settings, verified data log directory empty
3:41:00 PM	Test connections made, DMM acquisition began, DUTs connected, verified all iPhones charging
3:41:00 PM	Verified all iPhones in airplane mode, Wifi and bluetooth off.
3:41:00 PM	DUT 3 paired with iPhone-4 for quick test, there is only 1 LED remaining.
4:02:00 PM	DUT 3 powerbank depleted. iPhone 4 reached 86% battery capacity from 75%.
4:04:00 PM	Video recording stopped.